Amendments to the Specification:

Please replace the original specification with the attached substitute specification is attached along with a marked-up copy.

Amendments to the Abstract:

Please replace the original abstract with the following abstract.

ABSTRACT OF THE DISCLOSURE

In an environment in which storages are intensively collected, many unused areas are generated and no storage resources can be efficiently used as a storage pool.

———The capacity utilization (data capacity) of a storage device (volume) allocated to a computer is obtained and future capacity utilization is estimated from a change in the data capacity.

———Upper limit securing capacity and lower limit securing capacity ~~showing~~ values indicating the upper and lower limits of appropriate allocating capacity calculated from this estimated capacity utilization, and the capacity of the storage device are compared with each other. When the capacity of the storage device (old device) is greater than the upper limit securing capacity, the storage device (new device) of the lower limit securing capacity or more and the upper limit securing capacity or less is allocated from the storage pool, and the old device is collected in the storage pool.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (currently amended) A managing method to be executed by a management computer connected to a computer and storage apparatus through a network, ~~and~~ comprising the steps of:

~~a step for~~ allocating a storage area of predetermined capacity from the storage area of said storage apparatus to said computer;

~~a step for~~ obtaining the capacity utilization of ~~said~~ each storage area allocated to said computer;

~~a step for~~ calculating an estimated capacity utilization which is estimated from the capacity utilization of ~~said~~ each storage area; and

~~a step for~~ collecting ~~the~~ a storage area in which ~~corresponding to~~ the difference between the capacity of said allocated storage area and said estimated capacity utilization when the capacity of said allocated storage area is greater than said estimated capacity utilization.

2. (currently amended) The managing method according to claim 1, wherein

said collecting step includes the steps of:

~~a step for~~ allocating a second storage area of capacity equal to or greater than said estimated ~~using~~ capacity utilization and smaller than the capacity of ~~said~~ allocated first storage area to said computer; and

~~a step for~~ releasing the allocation of said first storage area to the computer after the ~~copy~~ copying of data of said first storage area to said second storage area is terminated.

3. (currently amended) The managing method according to claim 2, wherein said collecting step further ~~has:~~

~~a step for~~ includes giving commands to said storage apparatus so as to execute the ~~copy~~ copying of the data of said first storage area to said second storage area.

4. (currently amended) The managing method according to claim 3, wherein said collecting step further ~~has:~~

~~a step for~~ includes reducing the size of a file system made in the first storage area before the data ~~copy~~ copying is executed by the storage apparatus.

5. (currently amended) The managing method according to claim 2, wherein said collecting step further ~~has:~~

~~a step for~~ includes giving commands to said computer so as to execute the ~~copy~~ copying of the data of said first storage area to said second storage area.

6. (currently amended) The managing method according to claim 2, wherein said managing method further ~~has:~~

~~a step for~~ includes executing the ~~copy~~ copying of the data of said first storage area to said second storage area.

7. (currently amended) The managing method according to claim 1, wherein

said collecting step further ~~has:~~

~~a step for~~includes judging whether ~~the~~ collection of a storage area is possible ~~or not~~ on the basis of a flag for every ~~said~~ allocated storage area.

8. (currently amended) The managing method according to claim 1, ~~wherein the managing method~~ further including ~~has~~ a step ~~for~~ of obtaining a value indicating the number of write I/O ~~number~~ operations of ~~said~~ each storage area allocated to said computer, and

said collecting step includes the steps of:

~~a step for~~ assigning said storage area having 0 ~~in~~ as said write I/O number value for archive, and allocating a second storage area of low cost and having a capacity equal to or greater than said estimated capacity utilization and smaller than the capacity of said allocated first storage area to said computer; and

~~a step for~~ releasing the allocation of said first storage area to the computer after the ~~copy~~ copying of the data of said first storage area to said second storage area is terminated.

9. (currently amended) The managing method according to claim 1, wherein

said management computer is connected to plural storage apparatus, and

a memory for holding a device management table for managing the allocating states of the storage area of said plural storage apparatus is ~~arranged~~ provided,

said step ~~for~~ of allocating said storage area to said computer comprises allocating said storage area to said computer on the basis of said device management table.

10. (currently amended) The managing method according to claim 1, wherein said step ~~for~~ of calculating said estimated capacity utilization comprises calculating the estimated capacity utilization on the basis of the kind of an application for utilizing ~~said~~ each storage area, access characteristics or the degree of importance ~~degree of~~ stored data in addition to the capacity utilization of said each storage area.

11. (currently amended) The managing method according to claim 1, wherein on the basis of the capacity of said allocated storage area and said estimated capacity utilization, a proper state of the capacity of said allocated storage area is displayed. ~~,~~

12. (currently amended) A managing program to be executed by a management computer connected to a computer and a memory unit through a network, ~~and~~ for executing:

a procedure for allocating a storage area of predetermined capacity from the storage area of said storage apparatus to said computer;

a procedure for obtaining the capacity utilization of ~~said~~ each storage area allocated to said computer;

a procedure for calculating an estimated capacity utilization which is estimated from the capacity utilization of ~~said~~ each storage area; and

a procedure for collecting ~~the~~ a storage area ~~corresponding~~ in which ~~to~~ the difference between the capacity of said allocated storage area and said estimated

capacity utilization when the capacity of said allocated storage area is greater than said estimated capacity utilization.

13. (currently amended) A memory medium readable by a management computer connected to a computer and a storage apparatus through a network and storing a managing program to be executed by the management computer, wherein the memory medium stores the managing program for executing:

a procedure for allocating a storage area of predetermined capacity from the storage area of said storage apparatus to said computer;

a procedure for obtaining the capacity utilization of ~~said~~ each storage area allocated to said computer;

a procedure for calculating an estimated capacity utilization which is estimated from the capacity utilization of ~~said~~ each storage area; and

a procedure for collecting ~~the~~ a storage area ~~corresponding~~ in which ~~to~~ the difference between the capacity of said allocated storage area and said estimated capacity utilization when the capacity of said allocated storage area is greater than said estimated capacity utilization.

REMARKS

The specification has been amended to correct errors of a typographical and grammatical nature. Due to the number of corrections thereto, applicants submit herewith a Substitute Specification, along with a marked-up copy of the original specification for the Examiner's convenience. The substitute specification includes the changes as shown in the marked-up copy and includes no new matter. Therefore, entry of the Substitute Specification is respectfully requested.

The claims and abstract have also been amended to more clearly describe the features of the present invention.

Entry of the preliminary amendments and examination of the application is respectfully requested.

To the extent necessary, applicants petition for an extension of time under 37 CFR 1.136. Please charge any shortage in the fees due in connection with the filing of this paper, including extension of time fees, to the deposit account of Antonelli, Terry, Stout & Kraus, LLP, Deposit Account No. 01-2135 (Case: 501.43117X00), and please credit any excess fees to such deposit account.

Respectfully submitted,

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Title of the invention

Managing method for optimizing capacity of storage

BACKGROUND OF THE INVENTION

The present invention relates to a method for centrally managing plural storage ~~apparatus~~ devices.

In recent years, a technique for connecting a computer and plural storage ~~apparatus~~ devices by network (storage area network (SAN)) and centrally managing the plural storage ~~apparatus~~ devices connected to SAN ~~is~~ has been proposed.

As a method for managing ~~the~~ plural storage ~~apparatus~~ devices connected to a SAN, there is a technique for centrally managing a storage device (volume) ~~arranged in~~ among the plural storage ~~apparatus~~ devices connected to the SAN as a storage pool, and efficiently using the memory capacity of the storage device connected to the SAN.

In ~~the prior art~~ a conventional system, capacity is added by on-demand from a storage pool when the volume capacity become short due to insufficient estimation of the capacity being used, at ~~the~~ an insufficient time point. (For example, see ~~Patent Literature 1, etc.~~)

(Patent Literature 1) JP-A-2002-222061 (p.9, Fig. 11)

It is difficult to accurately estimate the capacity utilization in advance and to allocate the needed volume. In the ~~prior art~~ past, when the capacity utilization (data capacity) ~~is~~ was not increased as estimated, an unused storage area would remain and ~~it~~ would be never used.

In an environment in which ~~the~~ storage ~~apparatus~~ devices are intensively consolidated and many volumes exist, it will happen that many unused and useless storage areas remain unused. Since such unused storage areas in volumes are unused, but cannot be utilized as the storage pool, ~~a~~ the storage resources can not be efficiently used.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a managing method and a managing program to achieve high utilization of resources by collecting an excessively allocated storage area in a storage pool so as to utilize this storage area in another computer.

In one embodiment of the present invention, the capacity utilization (data capacity) of a storage device (volume) allocated to a computer is periodically obtained, and future capacity utilization is estimated from a trend ~~of~~ in the utilization of the data capacity.

Further, the capacity of ~~the~~ a storage device ~~are~~ is compared with an upper limit securing capacity and a lower limit securing capacity, ~~showing~~ representing the upper and lower limits of an appropriate allocating capacity, ~~and~~ which are calculated from the estimated capacity utilization. When the capacity of the storage device (old device) is greater than the upper limit securing capacity, ~~the~~ a storage device (new device) ~~of the~~ during a lower limit securing

capacity or more and ~~the~~ an upper limit securing capacity or less is allocated from the storage pool, and the old device is collected in the storage pool.

Further, in another embodiment of the present invention, maximum capacity utilization, minimum capacity utilization, the number of ~~read~~ read operations I/O and the number of ~~write~~ write operations I/O are periodically obtained in addition to the capacity utilization of the volume allocated to the computer. When the data capacity is constant and the number of ~~write~~ write operations I/O to a volume (old volume) is 0 for a certain period, data in the volume is marked as "archive" and is moved to a storage device of low cost so that the capacity of the old device is collected.

The other features of the present invention will become apparent ~~by~~ from the descriptions ~~of~~ provided in this specification and from the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a ~~constructional view~~ block diagram representing of a computer system ~~in~~ an embodiment of the present invention.

Fig. 2 is a ~~view~~ diagram showing the contents of an access control table of this embodiment.

Fig. 3 is a ~~view~~ diagram showing a GUI in a management computer of this embodiment.

~~Fig. 4 shows~~ Figs 4A to 4D are diagrams which show a data management table, addition securing capacity and an addition securing width management table of

this embodiment.

Fig. 5 is a diagram showing the contents of a capacity utilization management table of this embodiment.

Fig. 6 is a diagram showing the contents of a device management table of this embodiment.

Fig 7A and 7B are diagrams showing the contents of a network zone member management table and a network zone management table of this embodiment.

Fig 8A and 8B are diagrams showing the contents of a storage port management table and a computer port management table of this embodiment.

Fig. 9 is a flow chart showing the procedure of capacity utilization monitoring processing of this embodiment.

Fig. 10 is a flow chart showing the procedure of capacity collection processing of this embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 is a block diagram showing an embodiment of a computer system according to the present invention. The computer system 1 includes computers 200a, 200b, 200c, 200d (generally referred to as "computer 200"), a management computer 300, a fibre optic channel switch 50, Internet Protocol (hereinafter called "IP") networks 60 and 70, and a storage apparatus 400 (400a, 400b).

The storage apparatus 400 is connected to computers 200a and 200b through the fibre optic channel switch 50. The storage

apparatus 400 is also connected to computers 200c and 200d through the IP network 60. The storage apparatus 400 is further connected to the management computer 300 by the IP network 70.

The computers 200a and 200b, which are connected to the storage apparatus 400 through the fibre, optic channel switch 50, transfer data by using SCSI Protocol over Fibre Channel (hereinafter called "FCP") protocol. The computers 200c and 200d, which are connected to the storage apparatus 400 through the IP network 60, transfer data by using iSCSI protocol, which is able to transfer SCSI commands through the IP protocol.

The fibre channel switch 50 has a control unit, main memory, secondary storage and interfaces 52a, 52b, 52c, 52d, to the control unit to connect the computer 200 and the storage apparatus 400, and an interface 54 for connection with the IP network 70.

The storage apparatus 400 has a control unit 401 and at least one ~~a~~ hard disk drive 460. The control unit 401 has channel adapters 500a, 500b (generally referred to as ~~called~~ "channel adapter 500"), a cache memory 450, a shared memory 590, a disk adapter 550 and a crossbar switch 520. The channel adapter 500, the cache memory 450, the shared memory 590 and the disk adapter 550 are connected to each other by the crossbar switch 520. A bus, also may be ~~also~~ used instead of the crossbar switch 520.

~~The~~ Each hard disk drive 460 is connected to the disk adapter 550 through a port 570. The storage apparatus 400 may also have plural disk adapters 550. In this case, the plural disk

adapters 550 are connected to ~~the~~ respectively crossbar switches 520 ~~respectively~~. The plural hard disk drives 460 are connected to ~~the~~ respective disk adapters 550.

An identifier number is assigned to the channel adapter 500, and the channel adapter 500 is specified by this identifier (hereinafter called a "channel adapter ID").

The channel adapter 500a has fibre channel ports 402a, 402b and a processor 510a. The channel adapter 500a receives an I/O request based on the FCP protocol issued by the computers 200a and 200b through the fibre channel ports 402a and 402b.

The channel adapter 500b has IP network ports 404a, 404b and a processor 510b. The channel adapter 500b receives an I/O request based on the iSCSI protocol issued by the computers 200c and 200d through the IP network port 404a. The IP network port 404b is connected to the management computer 300. The channel adapter 500b communicates with the management computer 300 through the IP network port 404b.

The storage apparatus 400 has one or plural storage logical devices (hereinafter called logical devices) which serve as logical storage areas. The logical device corresponds to all or one portion of the storage area arranged in the hard disk drive 460. The logical device is a storage area recognized by the computer 200, and it is discriminated by a unique identifier within at least the computer system 1. The logical device is a device in which a block of 512 bytes in size is a minimum unit of data input

and output (I/O). In the block, a number started from 0 is marked from the head. The block is assigned by an LBA (Logical Block Address). The blocks are assigned a number, which starts from 0, from the head, and are specified by LBA (Logical Bloch Address), respectively. The capacity of the logical device is determined by the number of blocks, and it is increased as the number of blocks is increased. With respect to the logical device of this storage apparatus 400, the computer 200 requests I/O operations based on the FCP and the iSCSI.

The disk adapter 550 controls the operations of the cache memory 450 and the hard disk drive 460 within the storage apparatus 400, and it transfers data between the cache memory 450, the hard disk drive 460 and the channel adapter 500. For example, the disk adapter 550 also improves the reliability, performance of the storage apparatus 400, etc. by controlling the operation of the hard disk drive 460 as RAID having a redundancy property. The number of hard disk drives 460 arranged in the storage apparatus 400 may be set to a plural number or one.

The data transfer between the hard disk drive 460 and the channel adapter 500 is slower than the data transfer between the cache memory 450 and the channel adapter 500. Therefore, the storage apparatus 400 also improves the data transfer performance by storing frequently accessed data ~~to~~ in the cache memory 450.

Further, the storage apparatus 400 can limit the logical

device which is able to be accessed by the computer 200. Thus, for example, it is possible to prevent ~~that~~ the computer 200b from carelessly obtaining ~~gets~~ access to the logical device used by the computer 200a.

Fig. 2 shows an access control table 700 for performing access control from ~~the~~ a computer 200 by the storage apparatus 400. The access control table 700 is stored ~~to~~ in the shared memory 590. A device identifier that is used to discriminate the logical device of the storage apparatus 400, a storage port identifier of the storage apparatus 400 receiving the I/O request from the computer 200, the channel adapter ID of the channel adapter 500 having ~~the~~ a storage port, such as the fibre channel port 402a, etc., and a computer port identifier of the computer 200 that is permitted to access the storage apparatus 400 are registered to the access control table 700.

For example, if the port is the fibre channel port 402a, the storage port identifier and the computer port identifier are the port WWNs (World Wide Names) given to the ports. In contrast to this, if the port is the IP network port 404a, the storage port identifier and the computer port identifier are the IP addresses given to the ports. The channel adapter 500 executes I/O request processing to the logical device from the computer 200 with reference to this access control table 700 when the computer port identifier corresponding to the computer 200 that obtains ~~getting~~ access to the storage apparatus 400 is registered.

Similar to ~~the~~ a normal computer, the computer 200a has a control unit, a main memory, a secondary storage, a display unit, an interface 202a for connection with the switch 50, and an interface 204a connected to the network 70. The computer 200b is also similarly constructed.

Similar to ~~the~~ a normal computer, the computer 200c has a control unit, a main memory, a secondary storage, a display unit, an interface 202c for connection with the network 60 that is connected to the storage apparatus 400, and an interface 204c connected to the network 70 that is connected to the management computer 300. The computer 200d is also similarly constructed.

Similar to ~~the~~ a normal computer, the management computer 300 has a control unit, a main memory, a secondary storage, a display unit and an interface 304 connected to the network 70. The management computer 300 controls the operation of the storage apparatus 400 that is connected to the network 70 through the network 70 by reading a program (management application) stored to the memory unit to the memory and executing this program ~~by~~ upon the control unit. The management computer 300 can communicate with the computer 200 and the fibre optic channel switch 50 in addition to the storage apparatus 400 through the network 70.

In the processor 510b of the channel adapter 500b communicating with the management computer 300, a program (management agent) for communicating with the management

computer 300 is ~~operated~~ executed. The processor 510b receives setting and control request commands from the management application executed by the control unit of the management computer 300, and obtains, sets and changes states of the storage apparatus 400.

The management agent is also executed in the fibre channel switch 50 and the computer 200 as well as the storage apparatus 400. In the management application operated in the management computer 300, it is also possible to communicate with these management agents and obtain, set and change states of the fibre channel switch 50 and the computer 200.

Fig. 3 is a view showing a GUI (Graphical User Interface) displayed on a display screen arranged in the management computer 300 ~~and~~ used by a system administrator. In this figure, the logical device of the storage apparatus 400 is shown as a cylinder, and the computer 200 is shown as a rectangular shape. In this figure, when ~~the~~ a cylinder is displayed within the rectangular shape ~~showing~~ the computer 200, this cylinder shows that the computer 200 corresponding to this rectangular shape is set so as to ~~get~~ obtain access to the logical device shown by this cylinder in the storage apparatus 400.

Further, in this GUI, three areas designated excessively large allocation capacity, proper allocation capacity and excessively small allocation capacity are displayed, and the cylinder ~~showing~~ representing the logical device is displayed in one of these

three areas within the rectangular shape representing the computer.

In the excessively large allocation capacity area, the logical device which is excessively large in capacity in comparison with the capacity utilization in the computer 200 is allocated. The excessively large allocation capacity shows that the area of the logical device that is unused by the computer 200 is large, and it also shows a state in which the capacity utilization is low.

In the excessively small allocation capacity area, the logical device which is excessively small in capacity in comparison with the capacity utilization in the computer 200 is allocated. The excessively small allocation capacity shows that the area of the logical device that is used by the computer 200 is large, and it also shows a state in which the allocation of a larger logical device is desirable so as not to be deficient in capacity.

In the proper allocation capacity area, the logical device which area is proper ~~in~~ capacity in comparison with the capacity utilization in the computer 200 is allocated. The proper allocation capacity shows that the area of the logical device that is of the storage apparatus 400 unused by the computer 200 is necessary and sufficient.

The system administrator can confirm the allocating state of the logical device of the storage apparatus 400 with respect to the computer 200 by using this GUI.

Fig. 4A shows a data management table 900 which is managed by the management computer 300. The data management table 900 is

stored in the memory ~~arranged~~ in the management computer 300. The GUI of Fig. 3 is displayed on the display unit of the management computer 300 on the basis of this data management table 900. Information indicating ~~showing~~ a data identifier for uniquely discriminating data, the kind of application using the data, the computer using the data, a device identifier of the logical device of the storage apparatus 400, the capacity of the logical device, a lower limit securing ratio, an upper limit securing ratio, capacity collection yes/no, and the correspondence of the allocation state is registered in the data management table 900.

An entry of the management table 900 is made when a system administrator allocates a logical device of the storage apparatus 400 to a computer 200 using the management computer 300. At this time, the data identifier is created. The data identifier is a unique identifier given to data, and it is not changed even when the logical device for storing the data is changed. The identifier of the computer 200 allocating the logical device allocated thereto, the identifier of the allocated logical device, and the capacity of the allocated logical device are correspondingly stored.

The lower limit securing ratio and the upper limit securing ratio are set by selecting the characteristics of data to be stored to the logical device by the system administrator when the system administrator allocates the logical device to the

computer. The lower limit securing ratio and the upper limit securing ratio are used when lower limit securing capacity and upper limit securing capacity are calculated in capacity utilization monitoring processing 3000. The ~~allocating~~ state of the logical device to the data is determined by comparing the calculated lower limit securing capacity and upper limit securing capacity and the capacity of the logical device.

The application ~~kind~~ is set by selecting the data characteristics of the logical device ~~by the system administrator~~ when the logical device is allocated by the system administrator. The application ~~kind~~ is set to archive when it is judged ~~in~~ the capacity monitoring processing 3000 that there is no data update.

The capacity collection yes/no is used when it is judged whether capacity collection processing 1000 is executed in the capacity monitoring processing 3000 ~~or not~~. The system administrator sets the value of the capacity collection yes/no to no when it is not desirable to change the logical device for storing data by the capacity collection processing 1000 when the system administrator allocates the logical device.

The ~~allocating~~ state shows the state of capacity of the logical device of the storage apparatus 400 allocated with respect to the data, and is set by the capacity monitoring processing 3000. In the capacity monitoring processing 3000, the three allocating states of "excessively large",

"excessively small" and "proper" are set by comparing ~~among~~ the lower limit securing capacity that has been calculated ~~by~~ using the lower limit securing ratio, the upper limit securing capacity that has been calculated ~~by~~ using the upper limit securing ratio and the capacity of the logical device. Here, the upper limit securing capacity is greater than the lower limit securing capacity.

The state of "excessively large" size is a state in which the capacity of the logical device is greater than the upper limit securing capacity. The state of "excessively large" ~~shows~~ represents a state in which ~~the~~ a logical device of greater than required capacity ~~more~~ is allocated to the data.

The state of "excessively small" size is a state in which the capacity of the logical device allocated to the data is smaller than the lower limit securing capacity. The state of "excessively small" ~~shows~~ represents a state in which the required capacity of the logical device is insufficient for the data.

The state of "proper" size is a state in which the capacity of the logical device allocated to data is between the lower limit securing capacity ~~or more~~ and ~~is~~ the upper limit securing capacity ~~or less~~. The state of "proper" ~~shows~~ size represents a state in which ~~the~~ a logical device of ~~the~~ necessary and sufficient capacity is allocated.

The logical device that has been allocated to the data and which has an ~~of~~ "excessively large" or "excessively small" size as an ~~in the~~ allocating state becomes an object of the capacity collection processing 1000.

The lower limit securing ratio is a ratio (data amount is set to 100) with respect to the data amount of a minimum value (lower limit securing capacity) of the capacity of the logical device to be allocated to the data. The upper limit securing ratio is a ratio (data amount is set to 100) with respect to the data amount of a maximum value (upper limit securing capacity) of the capacity of the logical device which may be allocated to the data.

When there is a sudden increase in the data amount, a large free-space capacity can be secured in the logical device with respect to the data amount by increasing the lower limit securing ratio, so that a capacity deficiency of the logical device will not occur. By increasing the upper limit securing ratio, it is possible to prevent the capacity collection processing 1000 from being executed. When there is a large change causing a reduction in the data amount, the allocating state is judged as "excessively large" due to the temporal reduction of the data amount at the execution of the capacity utilization monitoring processing 3000. The upper limit securing ratio is set to be larger than the lower limit securing ratio in the same entry of the data management table 900, so as to set the upper limit securing capacity that is calculated from the data amount so that it is greater than the lower limit securing capacity.

The setting of the lower limit securing ratio and the upper limit securing ratio of the management table 900 performed

by the selection of data characteristics performed by a system administrator will be explained. The data characteristics selected by the system administrator include the kind of an application using the data, access characteristics with respect to the data, a degree of importance of the application using the data, etc. ~~as the data characteristics selected by the system administrator,~~ The lower limit securing ratio and the upper limit securing ratio are calculated from tables 970, 980, 990 in accordance with the selection of the system administrator.

The tables 970, 980, 990 are tables for managing an added amount (addition securing ratio) of the securing ratios to the lower limit securing ratio at the time of the selection of the data characteristics performed by the system administrator, and an added amount (addition securing width) of the securing width between the lower limit securing ratio and the upper limit securing ratio.

The lower limit securing ratio is calculated by adding the addition securing ratio corresponding to the data characteristics selected by the system administrator to 100. The upper limit securing capacity is calculated by adding the addition securing width corresponding to this lower limit securing ratio.

The table 970 is a table used for managing the addition securing ratio and the addition securing width in accordance with the kind of application. When the application is a database, the addition securing ratio is set to 10 and the addition securing

width is set to 5. When the application is a file server, the addition securing ratio is set to 20, such that no capacity deficiency is caused due to data inflation. Further, since a change causing a reduction in the data amount occurs when deleting a file, the addition securing width is set to 10. When the application kind is archive, it is considered that there is no increase in data. Therefore, the addition securing ratio is set to 0 and the addition securing width is set to 2.

The application kind selected by the system administrator is set to the application kind of the management table 900.

The table 980 is a table for managing the addition securing ratio and the addition securing width in accordance with access characteristics with respect to the data. In the case of only a operation read, there is no increase in data. Therefore, the addition securing ratio is set to 0 and the addition securing width is set to 2. When the access characteristics are write once, there is only an increase in data. Therefore, the addition securing ratio is set to 10 and the addition securing width is set to 2.

The table 990 is a table for managing the addition securing ratio and the addition securing width in accordance with the degree of importance of the data. The importance degree is such that the importance increases as the value of the importance degree is increased. When the importance degree is 1, the addition securing ratio

is set to 0 and the addition securing width is set to 2. When the importance degree is 2, the addition securing ratio is set to 10 and the addition securing width is set to 5. When the importance degree is 3, the addition securing ratio is set to 20 and the addition securing width is set to 10. Thus, as the importance degree is increased, the addition securing ratio and the addition securing width are increased.

When the system administrator selects the database as the kind of the application in the selection of the data characteristics, 105 provided by adding an added securing ratio of 5 managed in the table 970 to 100 is set as the lower limit securing ratio. 110 provided by adding a securing width of 5 managed in the table 970 to this lower limit securing ratio is set as the upper limit securing ratio.

The system administrator may also select plural data characteristics. For example, when the database is selected as the kind of the application and the write once is selected as the access characteristics and 2 is selected as the data importance degree, 30 as a sum of the addition securing ratio 10 of the database from the management table 970 of the application kind, the addition securing ratio 10 of the write once from the management table 980 of the access characteristics, and the addition securing ratio 10 of the importance degree 2 from the management table 990 of the importance degree, is added to 100. The added value 130 is set as the lower limit

securing ratio. Similarly, 20 as a sum of the addition securing width 5 of the database of the application kind, the addition securing width 10 of the write once of the access characteristics, and the addition securing width 5 of the importance degree 2, is added to the lower limit securing ratio 130. The added value 150 is set as the upper limit securing ratio.

When a system administrator does not select the data characteristics, the kind of the application, the lower limit securing ratio and the upper limit securing ratio in the data management table 900 are set by using "general" as the kind of the application.

Fig. 5 is a capacity utilization management table 910 managed by the management computer 300. The capacity utilization management table 910 is stored in the memory arranged in the management computer 300. Information showing the correspondence of the data identifier, an obtaining time as a time of obtaining of the capacity utilization, the capacity utilization at the obtaining time, an obtaining period showing a time passing from the previous obtaining to the present obtaining, maximum capacity utilization as a maximum value of the capacity utilization during the obtaining period, minimum capacity utilization as a minimum value of the capacity utilization during the obtaining period, the number of read I/O during the obtaining period, and the number of write I/O during the obtaining period is registered to the capacity

utilization management table 910.

The capacity utilization management table 910 exists for every data item distinguished by the data identifier, and it is used in the capacity utilization monitoring processing 3000 that is periodically executed by the management computer 300 when the capacity (capacity utilization of the logical device) of future data is estimated. Managing information obtained from the computer 200 is stored in the capacity utilization management table 910. When this table is filled with data, the data at the oldest obtaining time is overwritten.

Fig. 6 shows a device management table 800 that is managed by the management computer 300. The logical device of the storage apparatus 400 of the computer system 1 is centrally managed as a storage pool in this device management table 800. The device management table 800 is stored in the memory located in the management computer 300. Information indicating the correspondence of the device identifier of the logical device of the storage apparatus 400, the capacity, the cost and the computer 200 being used is registered to the device management table 800. The cost is set by the system administrator. For example, the cost of a logical device of high performance is set to be high. The computer being used designated by the identifier of a computer using the logical device is the designation. When there is no computer using the logical device, "non-existence" is set.

Fig. 7 A and B are diagrams showing a network zone member management

table 810 and a network zone management table 820, respectively. Information showing which network a port, such as a fibre channel port arranged in the storage apparatus 400 and the computer 200, etc., belongs to, is registered to the network zone member management table 810. Here, the port to which the same network identifier is allocated shows that the port belongs to the same network. Communication can be mutually made only between the ports belonging to the same network. This network zone member management table 810 is managed by the management computer 300, and is used when it is judged whether the communication can be made between two ports in the capacity collection processing 1000 executed from the capacity utilization monitoring processing 3000, periodically executed by the management computer 300.

Information showing the correspondence of the network identifier and a network name is registered to the network zone management table 820. For example, the network name corresponding to a network identifier 1 is "FC1".

Figs. 8A and 8B are diagrams showing a storage port management table 830 and a computer port management table 840, respectively. The identifier corresponding to the storage apparatus 400, the channel adapter number corresponding to the channel adapter 500 arranged in the storage apparatus 400, and the storage port identifier are registered to the storage port management table 830. The storage port management table 830 is managed by the management

computer 300, and it is used when the channel adapter 500 having the port and the storage apparatus 400 are retrieved from the storage port identifier in the capacity collection processing 1000 executed from the capacity utilization monitoring processing 3000 that is periodically executed by the management computer 300.

In contrast to this, a computer identifier ~~showing~~ indicating the computer 200 and a computer port identifier are registered ~~to~~ in the computer port management table 840. The computer port management table 840 is managed by the management computer 300, and it is used when the identifier corresponding to the port arranged in the computer 200 is obtained in the capacity collection processing 1000 executed from the capacity utilization monitoring processing 3000 that is periodically executed by the management computer 300.

In accordance with the present invention, the data amount (capacity utilization) of the logical device is periodically obtained. The lower limit securing capacity and the upper limit securing capacity that have been calculated from the lower limit securing ratio and the upper limit securing ratio set in the data and the capacity of the logical device allocated in the data are compared. The logical device is changed when the capacity of the logical device does not lie between the lower limit securing capacity and the upper limit securing capacity. In this embodiment, the capacity utilization monitoring processing is executed every

three weeks.

Fig. 9 is a flowchart showing the flow of the capacity utilization monitoring processing 3000 that is periodically executed by the management computer 300. By performing this processing it is determined whether the capacity allocated in the computer is appropriate or not. When this capacity is not appropriate, the logical device of the storage apparatus 400 is reallocated by the capacity collection processing 1000, which will be described later with reference to Fig 10. Thus, the capacity allocation of the computer system 1 is optimized. The function of the capacity utilization monitoring processing 3000 is realized by executing a managing program that has been loaded in the memory within the management computer 300 by the control unit. The managing program may also be introduced through a memory medium (CD-ROM, DVD-ROM, server, etc.) readable by the management computer 300 or a communication medium, such as a network or a carrier wave propagated on the network, which can be utilized by the management computer 300 at a necessary time. Further, one portion or all portions of the function of the capacity utilization monitoring processing 3000 may also be realized by hardware (LSI, etc.).

The management computer 300 obtains capacity utilization (data capacity), maximum capacity utilization (maximum data capacity), minimum capacity utilization (minimum data capacity), the number of read I/O operations and the number of write I/O operations as information relating to the monitoring object data managed by

the data identifier in the data management table 900 from the computer 200 using the monitoring object data through the network 70. The management computer 300 then stores such information in the capacity utilization management table 910 together with an obtained time and a passing time (obtained period) from the previous obtained time (step 3010).

When the capacity utilization, i.e. the maximum capacity utilization and the minimum capacity utilization from the past to the present time, are the same values and the number of write operations I/O is 0 with reference to the capacity utilization, the maximum capacity utilization, the minimum capacity utilization and the number of write operations I/O of the capacity utilization management table 910 with respect to the monitoring object data (step 3014) (when there is no data update), the application kind field of the data management table 900 corresponding to the monitoring object data is set to "archive", and the lower limit securing ratio is set to 100 and the upper limit securing ratio is set to 105 (step 3016).

When there is no case in which there is no data update in the step 3014, the management computer 300 estimates the future capacity utilization from the present capacity utilization and the past capacity utilization (step 3020).

In this embodiment, the expected capacity utilization is obtained by linearly extrapolating the capacity utilization at the next executing time point of the capacity utilization

monitoring processing 3000 from the newest capacity utilization obtained in the step 3010 and the capacity utilization previously obtained.

In other embodiment, accuracy of the estimation can be improved by estimating the capacity utilization by using more past data. When the expected capacity utilization calculated by using ~~the~~ past data is smaller than the maximum value of the maximum capacity utilization of the capacity utilization management table 910, the expected capacity utilization also can be ~~also~~ set to the maximum value of this maximum capacity utilization.

Further, when the capacity utilization is greatly increased and decreased and no accuracy of the estimation can be anticipated, the newest capacity utilization also may be ~~also~~ set to the estimated capacity utilization. The logical device may be set so as not to be changed by changing the capacity collection yes/no entry of the data management table 900 to no.

Next, the management computer 300 obtains the lower limit securing ratio and the upper limit securing ratio corresponding to the monitoring object data from the data management table 900, and it multiplies the expected capacity utilization calculated in the step 3020 by the lower limit securing ratio and the upper limit securing ratio, so that the management computer 300 obtains the lower limit securing capacity and the upper limit securing ratio (step 3030).

The capacity of the logical device allocated to the monitoring object data and the upper limit securing capacity obtained in the step 3030 are then compared with each other (step 3040). When the capacity of the logical device is equal to the upper limit securing capacity or less, the capacity of the logical device is compared with the lower limit securing capacity (step 3050). When the capacity of the logical device is equal to the lower limit securing capacity or more, the corresponding allocating state of the data management table 900 is set to "proper" (step 3090).

In contrast to this, when the capacity of the logical device is greater than the upper limit securing capacity in the step 3040, or when the capacity of the logical device is smaller than the lower limit securing capacity in the step 3050, the corresponding value of the capacity collection yes/no flag of the data management table 900 is referred to (step 3060). If the capacity collection is possible, the capacity collection processing 1000 is executed (step 3070).

In contrast to this, when the capacity collection is impossible in the step 3060, the corresponding allocating state of the data management table 900 is changed to "excessively large" if the capacity of the logical device is greater than the upper limit securing capacity, and it is ~~also~~ changed to "excessively small" if the capacity of the logical device is smaller than the lower limit securing capacity (step 3080).

The processing is then terminated.

Fig. 10 is a flowchart showing the flow of the capacity collection processing 1000 executed when it is judged in the capacity utilization monitoring processing 3000 that the capacity allocation of the logical device to the monitoring object data is inappropriate. The logical device of the storage apparatus 400 of appropriate capacity is allocated to the computer 200 and the original logical device is collected in a storage pool by performing this processing. The function of the capacity collection processing 1000 is realized by the control unit executing the managing program loaded in the memory within the management computer 300. The managing program may also be introduced through a memory medium (CD-ROM, DVD-ROM, server, etc.) readable by the management computer 300 or a communication medium such as a network or a carrier wave propagated on the network which can be utilized by the management computer 300 at a necessary time. Further, one portion or all portions of the function of the capacity collection processing 1000 may also be realized by hardware (LSI, etc.).

The management computer 300 retrieves a logical device of the upper limit securing capacity or less and the lower limit securing capacity or more that is unallocated to the computer from the device management table 800, and obtains the device identifier (step 1010). When the application kind of the monitoring object data indicates "archive", the condition that cost is low is added to

the retrieving condition. In ~~other~~ another embodiment, ~~the~~ a logical device of an intermediate value of the upper limit securing capacity and the lower limit securing capacity also can be ~~also made~~ obtained from an unused area of the storage apparatus 400. Such a technique is described ~~laid open~~ e.g., in JP-A-2002-222061.

As a result of ~~the~~ such retrieval, when there is a pertinent device, the management computer 300 obtains a list of storage port identifiers corresponding to the identifier of the logical device obtained in the step 1010 from the storage port management table 830 (step 1020).

Further, the management computer 300 obtains the computer 200 corresponding to data in which it is judged that the capacity allocation is not appropriate from the data management table 900. The management computer 300 also obtains a list of computer port identifiers corresponding to the computer 200 from the computer port management table 840 (step 1030).

Further, the management computer 300 makes a list of network identifiers corresponding to the storage port identifier obtained in the step 1020 by using the network zone member management table 810. At this time, when there are overlapped network identifiers, the management computer 300 excludes the overlapped network identifiers from the list and sets the overlapped network identifiers to one network identifier (step 1040).

Thereafter, the management computer 300 makes a list of

network identifiers corresponding to the computer port identifier obtained in the step 1030 by using the network zone member management table 810 (step 1050).

Thereafter, the management computer 300 compares the list of the network identifiers made in the step 1040 and the list of the network identifiers made in the step 1050 (step 1060).

When ~~there are~~ the same network identifiers are provided in both ~~the~~ lists, the management computer 300 obtains the storage port identifier corresponding to the network identifier ~~conformed~~ confirmed in the step 1060 from the list of the storage port identifiers obtained in the step 1020, and also obtains the computer port identifier corresponding to the network identifier ~~conformed~~ confirmed in the step 1060 from the list of the computer port identifiers obtained in the step 1030 (step 1065).

The management computer 300 further obtains a storage device identifier and a channel adapter number from the storage port management table 830 by using the storage port identifier obtained in the step 1065 (step 1070). Further, the management computer 300 adds the storage port identifier and the computer port identifier obtained in the step 1065 and the channel adapter number obtained in the step 1070 to the storage access control table 700 of the storage apparatus 400 corresponding to the storage device identifier obtained in the step 1070. More specifically, ~~Concretely~~, when an entry is added to the storage access control table 700, the management computer 300 gives commands of the

addition to the storage apparatus (step 1080).

Next, the management computer 300 copies data stored to the logical device (old device) judged as inappropriate capacity allocation with respect to the ~~above~~ computer 200 to a logical device (new device) retrieved in the step 1015 and set so as to be accessed from the ~~above~~ computer 200 in the step 1080 (step 2010).

The ~~copy~~ of ~~these~~ data can be executed by a copy command in the computer 200. Since the copy in the computer 200 is made by copying files, a long time is required to complete the copy so that the load of the computer 200 is raised. When load of the computer 200 can not be raised, the data can ~~also~~ be copied from the old device to the new device by copying the file in the management computer 300. It is necessary to inhibit writing to the old device to completely copy the data from the old device to the new device. Therefore, it is necessary to execute the copying operation ~~for~~ a time (e.g., nighttime) at which the operations are stopped and no ~~write~~ to the old device is ~~generated~~.

When read or write ~~to~~ the data stored to the old device can not be stopped for a long time, or when load can not be applied to the computer 200 and the management computer 300, the data copy can be ~~made~~ by using a function for ~~making~~ the data copy between the logical devices in the storage apparatus 400. Such a storage apparatus 400 is disclosed in US Patent

No. 5,051,887. When the capacity of the old device is greater than that of the new device and the number of blocks of the old device is greater than that of the new device, data stored to blocks of the old device of LBAs greater than a maximum LBA of the new device can not be copied to the new device. These blocks are set to unused states, and a partition of the old device is reduced to a partition having the same block number as that of the new device without losing the data. Thereafter, the data ~~are~~ is copied from the old device to the new device by utilizing the data copy function of the storage apparatus 400. The reducing ~~method of~~ the partition is disclosed in US Patent No. 5,675,769 ~~, etc~~. After the copy is terminated, the management computer 300 deletes the entry ~~corresponding to the above logical device~~ from the storage access control table 700 of the storage apparatus 400 ~~having~~ the logical device in which it is judged that the capacity allocation is inappropriate (step 2020).

Further, the management computer 300 updates the device identifier and the capacity corresponding to the ~~above~~ data of the data management table 900, and sets the allocating state to "proper". Further, the management computer 300 sets the ~~used~~ computer of the logical device which was judged as ~~the~~ an inappropriate capacity allocation in the device management table 800 to non-existence, and updates the ~~used~~ computer of a newly allocated logical device to the computer obtained in

the step 1030, and ~~terminates~~ the processing is then terminated.

When ~~there is~~ no pertinent device is found in the step 1015, or when no conforming ~~conformed~~ network identifier is found in the step 1060, the allocating state of the data management table 900 is changed to "excessively large" when the capacity of the logical device is greater than the upper limit securing capacity in a step 3040, and it is ~~also~~ changed to "excessively small" when the capacity of the logical device is smaller than the lower limit securing capacity in a step 3050 (step 1090). The processing is then terminated.

In accordance with the present invention, the capacity of the logical device of the storage apparatus 400 allocated to data is monitored by the management computer 300, and the logical device is changed when the allocating capacity is excessively large or excessively small. Therefore, the allocating state of the logical device of the storage apparatus 400 in the computer system 1 is automatically optimized, and the capacity can be efficiently used.

In accordance with the present invention, it is possible to provide a managing method and a managing program for efficiently using resources by collecting an excessively allocated storage area in a storage pool so as to utilize this storage area in another computer.